NMFS Expert Panel
ECOSYSTEM EFFECTS

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Question: *During the period of the fishery, has the carrying capacity of the ETP for dolphins declined substantially or has the ecological structure of the ETP changed substantially in any way that could have impeded depleted dolphin stocks from growing at rates expected in a static ecosystem? Or has the carrying capacity increased substantially or has the ecological structure changed substantially in any way that could promote depleted dolphin stocks to grow at rates faster than expected in a static ecosystem?*

Opinion: Physical changes have occurred in the Eastern Tropical Pacific (ETP) over the time period of the tuna purse seining fishery (late 1950s to present). These changes include a 1976 shift in the dominant mode of decade-scale variability in the Pacific (the Pacific Decadal Oscillation, PDO) and a possibly related increase in the occurrence of El Niño conditions. In my opinion, such changes provide a credible explanation for at least part of the observed slow recovery of dolphin stocks from the tuna fishery's impact. Observed year-to-year variations in the abundance of dolphin prey are significant in magnitude and consistent with this explanation in terms of direction (negative during El Niños). Unfortunately, the kinds of data needed support this view scientifically -- comparable measurements of prey abundance or dolphin population growth parameters extending from the 1960s to present -- are unavailable.

Explanation

Beginning in the mid-1970s and extending at least through 1997, the Pacific Ocean has been in what is known as the "warm phase" of the PDO cycle according to sea-surface temperatures measured along the eastern margins of the ocean. The approximately 2°C increase in average sea-surface temperature since the cold-phase period of the 1950s and '60s is seemingly modest. Nonetheless, by mechanisms that are not fully understood, the shift is associated with dramatic swings in the relative successes of different fisheries from Mexico to Alaska and similarly along South America. The temperature signature of this inter-decadal phase shift is evident in the ETP region (Admin. Rpt. LJ-02-16; Fiedler, 2002). In addition, climate time-series analyses has shown the enhanced occurrence of El Niños, or more precisely the diminished occurrence of strong La Niña cold conditions, over the same period of the mid-1970's to late 1990s (Barlow et al., 2001). Interannual variability associated with the El Niño-Southern Oscillation (ENSO) phenomenon is a dominant signal in the ecological characteristics of the ETP region, although somewhat suppressed in the core area of the tuna-dolphin fishery (Admin. Rpt. LJ-02-16; Fiedler, 2002).

It is fair to say that little data exist to support or reject significant effects of the 1976 PDO regime shift on the dolphin growth environment in the ETP. The NMFS studies began in 1979 after the shift, and the sparse data collected before then are generally insufficient to resolve long-term changes against the pronounced year-to-year differences that occur in this region. The NMFS science team did, however, compile historical data that show higher volumes of small planktonic animals (zooplankton) during the EASTROPAC expedition in Aug-Nov 1967 compared to data collected during the same months in 1998-2000 (Fig. 5 in Admin. Rpt. LJ-02-15; Fiedler & Philbrick, 2002). Both surveys broadly covered the ETP region with the same type of sampling procedures and during non-El Niño periods. While this limited data suggest a richer plankton in the ETP prior to the 1976 PDO shift, we cannot reasonably extrapolate that one-year observation to ecological differences that could affect dolphin growth rates over decades. The zooplankton is also not a direct food resource for dolphin or tuna, which feed on larger animals one or more steps further up the food chain. The dolphin prey are surface-dwelling flying fish, as well as various fish and squid that only migrate to the surface waters at night.

Following the food, as it were, night-time dip-netting surveys by NMFS investigators do, in fact, show substantial between-year variability in the prey animals for dolphins (Figures 2-9; Admin. Rpt. LJ-02-19; Pitman et al., 2002). Throughout the ETP, including the core area for depleted dolphin stocks, food resources appear to be strongly depressed during El Niño episodes (exceeding 10X differences among years for some prey types), followed by a gradual recovery phase of up to several years. Given the increased occurrence of El Niño conditions over the time period of interest as well as potential exacerbation by PDO warming, it is useful to consider how ENSO-driven fluctuations in prey abundance *could* influence population recovery rates of depleted dolphin species.

Stock management models assume that unexploited stocks were at or near the carrying capacity (K) in the pristine natural environment. However, if food resources are subject to large year-to-year swings, as they are in the ETP, K is more a moving target than an absolute. At any given time, even a pristine population may be increasing or decreasing depending on the currently available food resources for growth and the natural losses to predators, disease and aging. Slightly negative population trends during periods of reduced food (El Niños) would be balanced by positive growth during system recovery. Large El Niño kills are unlikely for relatively large, long-lived and highly mobile animals like dolphins. The effects would be more subtle (reduced calf production, decreased survival of young animals or delayed maturity of juveniles), and the population age structure would extend over many positive and negative years to give the appearance of a semi-steady state. The important point is not the precise mechanism or the magnitude of the effect, but the notion that environmentally driven variations in food abundance likely had an important regulatory influence on dolphin populations in their pristine state. In effect, one does not need to invoke massive ecological effects to explain net population growth rates of zero (the average state of a healthy pristine population). Other things equal, this condition is met by definition if the available food resources stay the same (as the pristine state) on average.

For dolphins to recover rapidly from the impact of the ETP fishery, they would have to benefit from their depleted stock condition, with enhanced conditions for growth or reduced rates of natural loss. Typically, we assume that reduced populations would exert less predatory pressure on their prey, leaving more food available for each surviving animal. That is not necessarily the case, however, if dolphin prey concentrations are determined more by variations in the quality of the prey's habitat (resources available to *them*, for example), rather than the impacts of predators on them. In addition, other animals with overlapping food requirements (i.e., competitors) could have increased during the decline of the depleted dolphin stocks and occupy part of the dolphin niche (and food resources) in the present system.

Following the points above to their logical conclusion, at least two ecological influences could act individually, jointly or in combination with other natural processes (e.g., increased vulnerability to natural predators, assuming that large schools have some protective function) to reduce the rate of recovery of depleted dolphins in the ETP to less than expected levels. 1) The combination of increased El Niño occurrences or the PDO shift could keep stocks of dolphin prey around pristine levels on average. 2) Enhanced abundances of competing species could contribute to this effect. The first of these scenarios would imply a temporary shift to a new ecological state with a reduced average K for the depleted dolphins. The second scenario would not necessarily require a change in K. Instead, an entrenched assemblage of competitors would have to be gradually replaced before the depleted dolphins could fully recover. While we cannot rule out this scenario, the fact that heavy fishing in the ETP has impacted many of the fish stocks that share food resources with the depleted dolphin populations would make a large cryptic increase in dolphin competitors somewhat unlikely.

Several factors make it difficult to establish stronger links between ecosystem-level variations in the ETP and dolphin growth potential or carrying capacity. First, there is a general lack of information on relevant ecological properties of the ETP (including prey fields and dolphin predators and competitors) prior to fishing impact and through most of the period of dolphin population collapse. This precludes a direct comparison of past and present conditions for dolphin growth in the ETP. Second, there appears to be little information available on indices of dolphin growth as might be deduced from analyses of animals killed during the fishery (e.g., estimates of age to maturity or age-length-weight relationships). Such measurements would provide the most straightforward approach for assessing net environmental influences on growth potential. Baseline information for pristine (1950s) stocks is unknown, and the fishery has provided very few samples for scientific analyses in recent years. Third, it remains unknown whether the association of tuna with dolphins is positive, negative or neutral with respect to the population growth potential of dolphins. Thus, while the reduction of tuna stocks by the fishery is one obvious biological change in the ETP over the past few decades, it is not clear whether it necessarily benefits the depleted dolphin stocks (for example, by reduced competition for food). The large mixed schools may afford dolphins some protection from predators or mutual advantages for exploiting food resources.

References:

Barlow, M., S. Nigam and E.H. Berbery. 2001. ENSO, Pacific Decadal Variability, and U.S. Summertime Precipitation, Drought, and Stream Flow. J. Climate, 14: 2105-2128.